

on the zone of contact between the gneiss and the limestones of the Berne Oberland; another most interesting work, on the distribution of heat in the interior of the St. Gothard Tunnel, is pursued by Dr. Stapff, and a preliminary notice about it, with maps, has just appeared in the Quarterly Reports of the Federal Council. (vol. vii.). It shows that the temperature of rocks increases to a great degree to the interior of the tunnel, being only 17° Celsius and $19^{\circ}7$ at the southern and northern extremities of the tunnel, and as high as $30^{\circ}8$ in the middle parts of it, the decrease at the outer ends being attributed by Dr. Stapff to the cooling influence of the water which circulates in the rocks. As to the geological information collected by Dr. Stapff during his work in the tunnel, which appears complete (with sixty sheets of maps and profiles) in the Reports of the Federal Council, a short *résumé* of the whole has already appeared in a separate fascicule of these Reports, with a geological outline of the tunnel. We notice also in this branch a valuable paper, by M. Salis, on the erosion of the Nolla River, tributary of the Rhine, which has appeared in the engineering paper, *Die Eisenbahn*, published at Zurich.

THE various races which inhabit Austria are studied by Dr. Goehrlert in the last number of the *Proceedings* of the Geographical Society at Vienna (vol. xxiv.), with respect to the length of the body. After having collected more than one and a half million of such measurements, which were done on recruits during the years 1870 to 1873, Dr. Goehrlert has dressed a map in which he has shown the average height of young men, twenty to twenty-three years old, in Austria. The Dalmatians are the tallest; next to them come the Serbo-Croats and Slovenes, and then the Germans and the Czechs; further down come the Ruthenes and Roumanians, and the smaller ones are the Magyars and Poles, especially the Mazours. But there are also two or three distinct average heights among the Germans, the Slaves, and the Magyars, those of middle Hungary, between the Danube and the Theiss rivers, being far taller than those of the flat country on the left bank of the Theiss. It is most probable, as M. Broca has shown with regard to France, that these notable differences of height among the same race show that there were two, or more, different branches which constituted what we consider now as a single race. As to the supposed decrease of height observed in France, Dr. Goehrlert supposes that in Bohemia, which has furnished during this century no less than 600,000 men to the Austrian armies, the decrease of average height can be estimated at little under 39 millimetres during the last hundred years, this decrease being due to the continuous taking away of tall men from the country. He shows also that, the standard height being the same for all provinces of Austria, the provinces where men are taller suffer proportionately more from recruiting.

THE seventeenth meeting of the Swiss Alpine Club was opened at Basel on September 10. The Annual Report shows that since its foundation the Club has built thirty-one huts, or *refuges* for climbers. The Club has also endeavoured to give a certain instruction to guides, and during this year an insurance society has been instituted for them. As to its publications, it has published sixteen volumes of year-books, which contain plenty of valuable information on the Swiss Alps, and publishes two papers, the *Écho des Alpes* and the *Neue Alpenpost*, which have contributed much to the development of Alpine literature. At its last meeting Mr. Ed. Whymper and the meteorologist, Prof. Hamon, were elected Honorary Members.

THAT part of the Ala-tau Mountains which is situated north-east from Tashkent, at the sources of the Arys, Talas, and Pskem Rivers, and which remained until now quite unknown, is described in the *Izvestia* of the Russian Geographical Society (vol. xvii. fascicule 3) by Col. Ivanoff. It is a very complex system of mountains, from 10,000 to 16,000 feet high, covered with mighty glaciers. The upper clefts have still conserved a good deal of forests, and the high Alpine pasturages are the grazing ground for the numerous herds of Kirghizes, as well as for the great species of *Ovis*, common to Thian-Shan. Col. Ivanoff has found numerous proofs that formerly the glaciers had a greater extension than now, and that they formed in the valley of the Maydan-tal River a mighty glacier which descended as low as 7000 feet, but he did not discover traces of a general glaciation.

HERR ERNST MARNO gives, in the last fascicule of the *Memoirs* of the Geographical Society of Vienna (vol. xxiv. Nos. 6, 7, 8, and 9), an interesting description of his expedition for the de-

struction of the *setts* of the Nile, that is, of the great grass-islands which are formed during the inundations of the steppes watered by the Bahr-el-Gebel and the Bahr-el-Abiad. The accumulation of grass which is driven away during the inundations constitutes, as is known, wide grass-islands, or *setts*, which bar up the river, and, when not cut through for several years, gradually increase by fresh grass and slime, and soon constitute true floating islands twelve and fifteen feet thick, which soon reach even the bottom of the river. It is with the greatest difficulty that Marno's steamer cut passages through these islands and destroyed the smaller ones.

WE see with pleasure that the Austrian Tourists' Club, which numbers as many as 300 members, has begun to publish fortnightly a *Tourists' Newspaper*, richly illustrated, which has as contributors many well-known scientific writers.

IN the *Monatsschrift für den Orient* for September, Herr von Schweiger-Lerchenfeld has a long article full of valuable information on Tripolitania, *à propos* of recent doings in North Africa. There is also an interesting letter from Ernst Marno on the Sudan.

IN the *Bulletin* of the Antwerp Geographical Society (tome vi. 3^e fasc.) M. L. Delavaud has brought together a number of valuable notes on the climate of Africa, interesting both from a scientific and a practical point of view.

THE last number of the *Izvestia* of the Russian Geographical Society contains papers, by M. Maëff, on the roads leading from Karshi to the Amu-daria River, and on the valleys of Vaksh and Kafirnahan; by M. Ivanoff on the upper parts of the Talas Alatau, and a map showing M. Mikluho-Maclay's travels in the Melanesian Islands.

THE eighth volume of the *Memoirs* of the Russian Geographical Society, for the section of ethnography, contains several valuable papers on the middle parts of the valley of Zerafshan, on the basin of Lob-nor, on the valley of Ferghana, on the Bekdons Shahrisabs, on the journey of Jenkinson to Khiva in 1559, on the Khiku-nor, and on the customs of the Tartars of Kazan.

IN a pamphlet entitled "Geography" Messrs. Ramsey, Millett, and Hudson have reprinted, from the Kansas City *Review of Science and Industry*, an interesting collection of official documents relating to United States Arctic colonisation and exploration in 1881. There are now no less than six expeditions in progress under Government control, which are divisible into two classes, one comprising those sent out for purposes of exploration and scientific research and the other those whose object is of a humanitarian nature. To the former class belong the *Jeannette*, Lady Franklin Bay, and Point Barrow expeditions, while the latter includes the *Rodfars*, *Alliance*, and *Corwin*, all chiefly engaged in searching for the *Jeannette* and missing whale-ships.

The just published *Bulletin* of the Belgian Geographical Society includes a paper by Capt. Verstraete on the great lakes of inter-tropical Africa from the fifteenth to the nineteenth century. There are also maps of Borneo, the new northern frontier of Greece, &c., which exhibit considerable roughness of execution.

ECONOMICS AND STATISTICS, VIEWED FROM THE STANDPOINT OF THE PRELIMINARY SCIENCES¹

THE object of the present paper is to show the relation of the preliminary sciences to statistics and economics, and to attempt to make the transition from the former studies to the latter simple and attractive to the scientific man. This must evidently be done by constructing a classification of social knowledge avoiding all immediate reference to practice. That such a classification does not at present exist cannot be better evidenced than by Mr. Baden-Powell, who has kindly drawn my attention to the conclusion of his paper, read on the previous day, "On Protection in Young Communities," in which he states the difficulties he has encountered in many departments of his researches because of the different methods of classification adopted in otherwise excellent statistical records, and insists that "uniformity in the method of registering statistical facts is of the utmost importance to comparative investigations," so that

¹ Abstract of a paper read before Section F of the British Association, 1881, by P. Geddes, F.R.S.E.

"it would be of great importance if such uniformity could be secured in the future."

A survey of the statistical records of various countries, whether under the same or different political rule, shows the most extreme discord, while a detailed examination of the schemes which have been as yet proposed by statisticians results in their rejection as unscientific—the very latest of such schemes being curiously analogous to the very earliest of classificatory attempts in biology. A criticism of the innumerable definitions of statistics, some of which claim statistics as a science, others as a method, others as both or neither, leads to the acceptance of the view recently sustained by Hooper (J.S.S. 1881), that statistics is simply a quantitative record of the observed facts or relations in any branch of science,—a definition which may conveniently be extended diagrammatically as follows:—

RECORD OF FACTS AT GIVEN TIME.

Qualitative	Quantitative			
	Numerical	Linear	Plane	Solid
		Graphic		
Statements.	Statistics.			

By combining such successive records we obtain history, and statistics and history are thus seen to be, within certain limits, the common property of the sciences—all save logic, where there are no ideas of quantity, being statistical, and all save logic, mathematics, physics, and chemistry, where conditions and properties are constant, being historical; the current notions of statistics and history as distinct sciences, or as distinct scientific methods, being therefore entirely erroneous.

The application of the above diagrammatic definition of statistics to all the sciences clearly illustrates the continual progress from qualitative to quantitative knowledge which goes on in each, and the increase of definiteness which quantitative knowledge constantly tends to assume. Thus while the common name of a chemical compound, say sulphate of iron, expresses only a qualitative relation, its ordinary chemical formula, FeSO_4 , reaches the numerical state, and its graphic and glyptic formulæ are respectively the plane and solid representations of the same relation of quantity. So, too, the astronomer has his star maps and orrery, the biologist his figures and diagrams, while the sociologist so often requires similar aid that the French Government has recently established a Bureau de Statistique Graphique. So by piling up successive graphical representations of statistical observations, a solid historical model might often be constructed. A geologist, for instance, by piling map upon map of a given island at successive times (the margin being, of course, cut away) would thus construct a solid model which would graphically exhibit the changes of increase and decrease, local and general, throughout the entire period.

But what are the desiderata of a system of classification? It must be natural, not artificial,—capable of complete generalisation and specialisation, universal in application, simple of understanding, and convenient in use. Immeasurably the highest example of such a classification is presented by botany and zoology, and it is therefore the biologist, not the logician or the mathematician, and still less the metaphysician or the political economist, whose training prepares him to undertake the still vaster task of classifying the infinitely numerous and varied phenomena of society.

Taking an actual compendium of miscellaneous statistics, we have first then to separate out in order the actual statistics of the preliminary sciences, mathematical, physical, chemical, astronomical, geological, &c., and leave these to their special cultivators. Social statistics now alone remain, and to classify these naturally we must ascertain the fundamental scientific truths respecting society. Just as the biologist is accustomed to classify man along with inferior organisms, and to trace the fundamental resemblances in structure and function which his organisation presents to theirs, so he must inquire wherein human society resembles the societies formed by the lower animals, the more so as no one disputes that these fall strictly within his province (see Huxley, "Anat. Invert." p. 1). As the term indeed assumes, some general truths must be common to societies of *Formica*,

Apis, *Castor*, and *Homo* alike, and this must therefore underlie our classification of social facts.

First, then, a society obviously exists within certain limits of space and time. It consists of living organisms. Again, the-e modify surrounding nature, primarily by seizing part of its matter and energy. Again, they apply this matter and energy to the maintenance of their life; *i.e.* the support of their physiological functions. Finally, these organisms are modified by their environment.

These *sociological axioms*, as we may henceforth term them, at once enable us to classify out the facts relating to each and every society as follows: (A) those relating to the limits of time and space occupied by the society; (B) those relating to the matter and energy utilised by the society; (C) those relating to the organisms composing the society; (D) those relating to the application of the utilised matter and energy by the given society; (E) those relating to the results of the preceding conditions upon the organisms. These considerations were developed in a series of tables exhibited as diagrams upon the wall; and an extremely condensed summary is given on the following page.

These tables, which may be read either separately, in horizontal, or in vertical series (the left-hand vertical series being viewed as entries on the creditor side of a balance sheet), were developed into detail, and shown to be applicable to all societies alike, whether animal or human, civilised or savage, and to include the facts (A) of political geography; (B) of economic physics, geology, botany, and zoology, of technology and the fine arts, transport and commerce, in short, of the economics of production; (C) of anthropology, together with the Registrar-General's reports and the census; (D) of distribution and consumption; (E) of a large body of observations made by physicians, biologists, educationists, and philanthropists dealing with the modifications of the organisms by their environment. These tables, therefore, while endeavouring to classify all known statistics, attempt nothing short of an organisation of the social sciences into a more definite and coherent body of knowledge than they have formed heretofore.

It was then shown that while the above outlined considerations are in entire harmony with the economic labours of the geographer, the physicist, the biologist, the anthropologist, and the demographer, they furnish grounds for a destructive criticism of the existent systems of political economy, in so far as these pretend to intellectual completeness; the best proof of this being their applicability to utilise and reconcile the labours of each and all the contending schools, statistical and economical alike.¹

The application of the conceptions of physics and biology to the interpretation of social facts was then alluded to, interest on money being taken as an example. This was shown to depend neither upon compensation for risk of loss, reward for abstinence, nor wages of superintendence, as asserted by economists (Fawcett, "Pol. Econ."), nor yet to be simply an abstraction from the wealth of other members of the community as supposed by its opponents, but usually to arise, in modern times at least, from the appropriation of the matter and energy of nature, and generally speaking, from the exploitation of the sun.

But the severest test which can be imagined is to apply the ideas of the present paper to the study and classification of all the other papers read during the meeting of the section, since no preparation within such short limits of time has been possible. The first, "On Societies of Commercial Geography," relates to the study of territory (Tables A); the second, "Corn or Cattle," in the language of Table B, I., inquires whether the exploitation of plants or animals be more profitable in the given society; the third, "Report of Committee on Teaching," &c., relates to the state and treatment of cerebral functions of certain organisms in the given society; the fourth, "On Agricultural Statistics and Prospects," is at once classified with the second; the fifth, "A General Banking Law," &c., relates to the co-ordination of commerce (Table B, II., Movement), and so on.

So, too, with the anthropological papers:—the first, "Report on Caves and Kitchen-Middens," is a statement of facts respecting production, partition, and consumption in some ancient community, while the next, "On the Stature of the Inhabitants of Hungary," supplies facts to be classified under Hungary, organisms, structure. Nor are the other sections behind in furnishing

¹ The preceding propositions and tables are abridged from the author's paper "On the Classification of Statistics and its Results" ("Proc. Roy. Soc. Edin." 1881).

CLASSIFICATION OF STATISTICS.

SOCIETY DATE

A.—TERRITORY. I. QUANTITATIVE.						TERRITORY. II. QUALITATIVE.			TERRITORY. III. DECREASE.				
Existent at last recorded time.		Increase.				Unused.	Used.		By social agency.	By geologic agency.			
		By social agency.		By geologic agency.			Unspecialised.						Specialised.
B.—PRODUCTION.						II. DEVELOPMENT OF ULTIMATE PRODUCTS.			III. LOSS. (PREMATURE DISSIPATION OF ENERGY AND DISINTEGRATION OF MATTER.)				
I. a. SOURCES OF ENERGY IN TERRITORY.						Energy.	Exploitation, manufacture, and movement (trade and transport).	Ultimate products.	Agency.	In			
Primitive chemical affinity.	Earth's internal heat.	Earth's rotation.	Solar radiation.							Physical, Biological, Social.	Exploitation, manufacture, movement, remedial effort, &c.		
			Kine-tic.	Potential.									
				Earth's crust.	Organisms.	See Table I. a.							
						Matter.							
β. SOURCES OF MATTER USED FOR OTHER PROPERTIES.													See Table I. β.
Mineral.		Vegetable.		Animal.									
C.—ORGANISMS. I. QUANTITATIVE.						ORGANISMS. II. QUALITATIVE.			ORGANISMS. III. DECREASE.				
Existent at last recorded time.		Increase.				Biological.		Social.	Emigration.		Death.		
		Immigration.		Birth.		Structure.	Function.	Mutual relations.					
C.—ORGANISMS. OCCUPATIONS. I. (OPERATIONS ON MATTER AND ENERGY.)						OCCUPATIONS. II. DIRECT SERVICES TO ORGANISMS.			OCCUPATIONS. III.				
Exploitation.		Manufacture.		Movement.		Of non-cerebral func'ns.		Of cerebral functions.	Of co-ordination.	Unemployed.	Disabled.	Destructive.	Remedial.
D.—PARTITION (MEDIATE AND ULTIMATE) TO CLASS I.						PARTITION TO CLASS II.			PARTITION TO CLASS III.				
D.—USE BY CLASS I.						USE BY CLASS II.			USE BY CLASS III.				
E.—RESULT TO CLASS I.						RESULT TO CLASS II.			RESULT TO CLASS III.				

papers essentially economic: witness the numerous interesting papers read to Sections A and G, on the applications of electric energy, and, best of all, the presidential addresses to those sections, of which both were devoted to economic physics, or rather, as the subject should be called, physical economics.

Finally, if the preceding axioms and the soundness of the above classification of social facts be not disproved, it follows that three out of the four great reforms demanded in Mr. Ingram's presidential address,¹ and repeated and enforced in Mr. Grant Duff's, are here introduced into the conduct of economic research, namely, "(1) that the study of the economic phenomena of society ought to be systematically combined with that of the other aspects of social existence; (2) that the excessive tendency to abstraction and to unreal simplifications should be checked; (3) that the *a priori* deductive method should be changed for the historical; while the fourth, that economic laws and the practical prescriptions founded on these should be conceived and expressed in a less absolute form," would readily also be exemplified if the limits of the present paper permitted reference to generalisation and to practice. Again, it is sufficient to quote Mr. Ingram's concluding proposals to show that these have been substantially adopted. The field of the section should be enlarged so as to comprehend the whole of sociology, "since the economic facts of society . . . cannot be scientifically considered apart, and there is no reason why the researches of Sir Henry Maine or Mr. Spencer should not be as much at home here as those of Mr. Fawcett or Prof. Price. Many of the subjects, too, at present included in the artificial assemblage of heterogeneous inquiries known by the name of anthropology really connect themselves with the laws of social development, and if our section bore the title of the sociological, the studies of Mr. Tylor and Sir John Lubbock would find in it their most appropriate place. I prefer the name sociology to that of social science."²

THE PROPER PROPORTIONS OF RESISTANCE IN THE WORKING COILS, THE ELECTRO-MAGNETS, AND THE EXTERNAL CIRCUITS OF DYNAMOS³

FOR the electro-magnet;

Let L be the length of the wire,

B ,, bulk of the whole space occupied by wire and insulation,

n ,, ratio of this whole space to the bulk of the copper alone (that is, let $\frac{1}{n}B$ be the bulk of the copper),

A ,, the sectional area of wire and insulator,

R ,, the resistance of the wire.

For the working coil, let the corresponding quantities be L' , B' , n' , R' . Lastly, let s be the specific resistance of the copper. We have—

$$B = AL$$

$$R = ns \frac{L}{A} = ns \frac{B}{A^2}.$$

$$\text{Hence, } A = \frac{\sqrt{nsB}}{\sqrt{R}} = \frac{K}{\sqrt{R}} \quad (1)$$

$$\text{and similarly, } A' = \frac{\sqrt{n's'B'}}{\sqrt{R'}} = \frac{K'}{\sqrt{R'}} \quad (2)$$

where K and K' denote constants.

Now, let c be the current through the magnet coil, and c' that through the working coil, and let v be the velocity of any chosen point of the working coil. Denoting by p the average electro-motive force between the two ends of the working coil, we have—

$$p = I \frac{c}{A} \frac{1}{A'} v. \quad (3)$$

where I is a quantity depending on the forms, magnitudes, and relative positions of B and B' , and on the magnetic susceptibility of iron; diminishing as the susceptibility diminishes with increased strength of current, or with any change of R and R' which gives increase of magnetising force.

In the single-circuit dynamo (that is, the ordinary dynamo) c' is equal to c , but not so in the shunt-dynamo. In each, the

whole electric activity (that is, the rate of doing work) is $p c'$; or, by (3)—

$$I \frac{c c'}{A A'} v \quad (4)$$

or, by (1) and (2)—

$$\frac{I \sqrt{(R R')} c c' v}{K K'} \quad (5)$$

Of this whole work, the proportions which go to waste in heating the coils and to work in the external circuit are—

$$R c^2 + R' c'^2 \quad \text{waste} \quad (6)$$

$$\frac{I \sqrt{(R R')} c c' v}{K K'} - (R c^2 + R' c'^2) \quad \text{useful work} \quad (7)$$

By making v sufficiently great, the ratio of (6) to (7) (waste to useful work) may be made as small as we please. Our question is, how ought R and R' to be proportioned to make the ratio of waste to work a minimum, with any given speed? or, which comes to the same thing, to make the speed required for a given ratio of work to waste a minimum? To answer it, let r be the ratio of the whole work to the waste. We have, by (5) and (6)—

$$r = \frac{I \sqrt{(R R')} c c' v}{R c^2 + R' c'^2} \frac{1}{K K'} \quad (8)$$

For the single-circuit dynamo we have $c = c'$, and (8) becomes—

$$r = \frac{I \sqrt{(R R')} v}{R + R'} \frac{1}{K K'} \quad (9)$$

or

$$r = \frac{I \sqrt{\frac{1}{2} R (S - R)}}{S K K'} \quad (10)$$

where

$$S = R + R' \quad (11)$$

Suppose now S to be given, and suppose for a moment I to be constant. The problem of making r a maximum with v given, or v a minimum with r given, requires simply that $R (S - R)$ be a maximum; which it is when $R = \frac{1}{2} S$, that is, when the resistances in the working coil and the electro-magnet are equal. But in reality I is not constant; it diminishes with increase of the magnetising force. As it generally depends chiefly on the soft iron of the electro-magnet, and comparatively but little on the soft iron of the moving armature, or on iron magnetised by the current through the moving coils, it will generally be the case that I will, *ceteris paribus*, be diminished by increasing R and diminishing R' . Hence the maximum of r/v is shown by (10) to require R' to be somewhat greater than $\frac{1}{2} S$: how much greater we cannot find from the formula, without knowing the law of the variation of I .

Experience and natural selection seem to have led in most of the ordinary dynamos, as now made, to the resistance in the electro-magnet being somewhat less than the resistance in the working coil, which is in accordance with the preceding theory.

Whether the useful work of the dynamo be light-giving, or power, or heating, or electro-metallurgy, we may, for simplicity, reckon it in any possible case by referring to the convenient standard case of a current through a conductor of given resistance E connecting the working terminals of the dynamo. This conductor, in accordance with general usage, I call the "external circuit," which is an abbreviation for the part of the whole circuit which is external to the dynamo. In the case of the single-circuit dynamo the current in the external circle is equal to that through the working coil and electro-magnet, or c of our notation. Hence, by Ohm's law—

$$c = \frac{p}{E + R + R'} \quad (12)$$

or, by (3), (1), and (2),

$$c = \frac{I \sqrt{(R R')} v}{K K' (E + R + R')} \quad (13)$$

Hence either

$$c = 0 \quad (14)$$

or

$$I = \frac{K K' (E + R + R')}{\sqrt{(R R')} v} \quad (15)$$

The case of $c = 0$ is that in which

$$v < \frac{K K' (E + R + R')}{I_0 \sqrt{(R R')}} \quad (16)$$

where I_0 denotes the value of I for $c = 0$. To understand it, remember we are supposing no residual magnetism. For any speed subject to (16), the dynamo produces no current. When this limit is exceeded the electric equilibrium in the circuit becomes unstable; an infinitesimal current started in either direction rises rapidly in strength, till it is limited by equation (15), through the diminution of I , which it produces. Thus,

¹ "On the Present Position and Prospects of Political Economy" (British Association, Dublin, 1878).

² Quoted by Mr. Grant Duff, Presidential Address to Section F, 1881.

³ Paper read at the British Association, York, 1881, by Sir William Thomson, F.R.S.